child and was able to lead a more normal life without any form of drug therapy. At the end of the four-year period of observation she remained well.

Conclusion

Though relatively few patients were involved in this exercise, the time and effort required to arrest legal prescribing of amphetamines was disproportionately high. On the whole the method used produced acceptable results. The number of patients who could be regarded as addicted was probably only three. For them, the abandoning of legal prescribing seemed to be of little consequence in so far as two committed suicide and one continued illegal association with amphetamines. It was, however, apparent that amphetamines had made no significant contribution to the relief of depression and the drug may, for some women, have created more problems than were relieved. The arrest of prescribing for these patients was a necessary precursor of more effective treatment. The exercise also showed in a small way that some patients attach a high degree of significance to consultant opinion and are willing to use such opinion to manipulate the action of the general practitioner.

The problems presented by the voluntary withdrawal of amphetamine prescribing should not be underestimated. Suicide can provoke powerful emotional reactions in the doctor. The supportive role of a sympathetic coroner was a significant contribution which allowed me to continue to pursue a policy which might otherwise have been abandoned.

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Medical History

Gelsenkirchen Typhoid Epidemic of 1901, Robert Koch, and the Dead Hand of Max von Pettenkofer

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In 1901 there was in Gelsenkirchen, in the Ruhr valley, an outbreak of typhoid fever that claimed over 3,000 victims, 8% of whom died. This outbreak was the subject of an official investigation that lasted for two and a half years and resulted in the criminal prosecution of the two directors of the Gelsenkirchen waterworks, E. Hegeler and K. Pfudel, its engineer, M. Schmitt, and its chief mechanic (*Maschinenmeister*), H. Kiesendahl.[1] A contemporary German waterworks engineer, E. Grahn, to whom we owe the most detailed account of this judicial process, wrote at the time that the whole educated world had awaited the verdict with an "almost feverish tension."[2]

That this was so is hardly surprising for the chief expert witness for the prosecution was no less a person than Robert Koch—then a medical scientist of world-wide renown—while the chief defence witness was Rudolf Emmerich, who had succeeded Max von Pettenkofer in the Chair of Hygiene at the University of Munich. In spite of the crucial importance of this trial to public health, and of the eminence of rival expert witnesses, it has been completely overlooked by historians of medicine.

Pettenkofer and his "Localist" School

To understand the issues that were to be tested at this trial it is necessary to turn the clock back to 50 years before, when the mode of transmission of the two water-borne diseases par excellence—cholera and typhoid—was unknown and hotly disputed. In 1849 John Snow, of London, and William Budd, of Bristol, almost simultaneously postulated that cholera was a primarily water-borne disease due to a living organism. In 1855 Snow reinforced this theory in a work that has long been recognized as a classic of epidemiological reasoning. It was also in 1855 that Max von Pettenkofer of Munich criticized Snow's publication of six years before claiming that the history of cholera epidemics in his city offered a striking proof that the disease was *not* water borne.[3] His epidemiological investigations had, he affirmed, disposed "once and for all" of the idea that drinking water could spread cholera, and it was contamination of the soil by human faeces and urine that gave rise to a "cholera-miasm." Ten years later he was referring to "typhoid and other soil-diseases."[4] In the following year, 1866, the third International Sanitary Conference at Constantinople—which lasted for no less than seven months—was dominated by Pettenkofer's fallacious a priori reasoning and voted unanimously that air was the main vehicle of the "generative principle" (whatever it was) of cholera.[5]

In 1869 Pettenkofer once again returned to the attack, sarcastically referring to the "one and only drinking-water faith"—which he dismissed as "downright impossible"—quoting with approval an English sanitarian, Jabez H. Ogg, as having said that "the water theory would no longer hold water."[6] Pettenkofer's own explanation was that there was a cholera germ (*Cholerakeim*), which he designated x, that came from India but could not by itself produce cholera. In suitable conditions of place and time there was in the soil a substrate, y, which united with x to produce z. It was z that was "the real cholera poison," and x without y was harmless.

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Robert Koch isolates the Cholera Vibrio

In 1884 Robert Koch, leader of the German Cholera Commission that had studied the disease first in Egypt and then in India, announced from Calcutta that he had isolated the "comma bacillus" (*Vibrio cholerae*) and incriminated it as the cause of cholera.[7] On his return to Berlin in the same year, Koch was fêted as a national hero, being awarded, inter alia, the Order of the Throne, Second Class with Star, and a life-sized bust of the Kaiser. Pettenkofer, however, was not impressed. "Koch's discovery of the comma bacillus," he wrote, "alters nothing, and, as is well known, was not unexpected by me."[8] All that Koch had done, according to Pettenkofer, was to identify *x*, which was harmless unless it combined with *y* to form *z*. Ten years later he was to sneer at the futility of "zealous comma-hunting."[9]

Pettenkofer had influential disciples in all Europe and especially in the home of cholera—British India. In England, Professor John Burdon-Sanderson of Oxford in 1885 described Koch's discovery as "an unfortunate fiasco."[10] In the same year a British medical mission, which included the young C. S. Sherrington (later Sir Charles, and a Nobel laureate) went to study cholera in Spain and reported, as had another British medical mission to India in the previous year, that the cholera bacillus was not the cause of cholera.[11] For the leader of the latter mission Pettenkofer was "the greatest living authority on the etiology of cholera."[12]

Pettenkofer's "Proof" of his Theory

In 1892 a fearful epidemic of cholera in Hamburg claimed, according to statistics published by Koch, almost 17,000 victims of whom slightly more than half died.[13] On 12 November of that year Pettenkofer delivered to the Munich Medical Society a long disquisition on the epidemic in which he reasserted his faith in his mythical alphabetical trinity—*x*, *y*, and *z*.[14] But this trinity had undergone a curious metamorphosis. Koch's comma bacillus was still *x*, but *y* was "temporo-spatial disposition" while *z* was "individual disposition."

In his disquisition Pettenkofer gave a superfluously circumstantial account of what he thought to be a crucial autoexperiment. On 7 October he had neutralized his gastric juices with sodium bicarbonate and then, in the presence of witnesses, swallowed 1 ml of a broth culture of cholera vibrios. He estimated that his "cholera drink" contained a thousand million vibrios, but was firmly convinced that "*x* could not do away with me without my *y*." The only consequences were borborygmi and a relatively mild diarrhoea. Colleagues who harvested his stools found in the more watery specimens a "pure culture" of vibrios. Pettenkofer's most faithful disciple, Rudolf Emmerich, performed a similar autoexperiment with much more drastic results, having to go to stool almost hourly for two days and yielding, as had his master, "pure cultures" of vibrios. But both Pettenkofer and Emmerich interpreted their malaises as disproving Koch's explanation of the aetiology of cholera. Koch and his followers, said Pettenkofer, might allege that he and Emmerich had had mild attacks of cholera; "I am glad to give my adversaries this pleasure, but on epidemiological grounds I cannot accept that *x* and *z* suffice for cholera epidemics without any *y*."

Gelsenkirchen Typhoid Epidemic

One Saturday night early in 1901 Pettenkofer, then in his 83rd year, blew out his brains with a pistol, and some months later the Gelsenkirchen typhoid epidemic occurred. The criminal prosecution of those administratively and technically responsible for the local waterworks opened on 4 July 1904, but after a hearing of 10 days was adjourned for further technical investigations. In reopened on 14 November and concluded on the 30th of the same month.

The indictment was based on a German law of 1879 that made it a penal offence to purvey foodstuffs that could be injurious to health and offer a threat to life. It was common ground that at times when the level of water supply threatened to become inadequate for industrial needs an emergency pipe was opened to admit untreated water from the Ruhr river. Robert Koch and several other distinguished expert witnesses for the prosecution maintained that it was the deliberate admixture of this impure Ruhr water that was responsible for the typhoid epidemic. Arthur Springfeld, an eminent authority on forensic medicine, agreed in incriminating a contaminated water supply, but attributed this to an accidental rupture of a pipe. Rudolf Emmerich, however, entirely repudiated the idea that typhoid could be transmitted by drinking water, declaring at the trial: "Gentlemen, it is my firm, solemn conviction that water plays no role here, but that soil-relationships carry the responsibility."[15] Thus was the court confronted by three different and irreconcilable technical explanations of the cause of the epidemic each of them advanced by expert medical witnesses of the highest credentials.

The first line of the defence was that the provisions of the law of 1879 were not relevant, as water was not a foodstuff. This contention was supported by Emmerich, who said that while water was essential to life, so was air, and no one would place air in the category of foodstuffs. Koch, on the contrary, stated that he regarded water as a foodstuff, and the judge ruled in his favour on this point. The defence then attempted to assail Koch's credibility. In October 1901 he had been sent by the German Minister of Culture to Gelsenkirchen to investigate the circumstances of the epidemic, and on the 21st of that month he had reported to the Minister, incriminating as its cause the admission of untreated Ruhr water via the emergency pipe. But, asked the defence, had he not on 18 October delivered a public lecture in which he affirmed his belief in Springfeld's theory of an accidental rupture of a pipe? Koch had to agree that this was so, but explained that at the time public feeling against the water company was running so high that he did not wish to add fuel to the flames by expressing his real conviction. Thus did Koch admit that he had lied in public for reasons of pure expediency.

During the remainder of the trial, the main point at issue was the validity or otherwise of the doctrine of Pettenkofer, who had then been dead for almost four years. For the prosecution Professor Walther Kruse of Bonn alleged that Pettenkofer had never clearly explained his theories but had enveloped them in "a mystical obscurity." They were "the product of an inventive imagination" built on "really drastic hypotheses that are entirely contradicted by the real facts." For Professor Karl Wilhelm von Drigalski of Saarbrücken, Pettenkofer's theories were "nonsensical" (*unsinnig*).

Emmerich began his testimony for the defence by expressing his surprise that a Prussian public prosecutor should bring before a legal forum a scientific controversy. The theory that the epidemic was water-borne was based solely on "circumstantial evidence" (*Indizienbeweis*)—a truly remarkable assertion when it is considered that Emmerich's explanation was based on non-existent circumstances. Explaining Pettenkofer's soil-theory (*Bodentheorie*), Emmerich stated that the typhoid bacillus was harmless to man until it had undergone for a period of some months a process of maturation in the soil, after which it could be transmitted to man "through the air."

Emmerich then went on to outline his and Pettenkofer's experiments of 12 years ago with cultures of the cholera vibrio. He admitted that he had had diarrhoea, "but none of the associated manifestations of cholera (leg cramps, etc)." Koch intervened to say that he believed that he still had a letter from Emmerich stating that he had been severely ill and had had leg cramps. Emmerich disdained a reply to

Koch's comment, but stated with monumental irrelevance that in 1384 A.D. thousands of Jews had been burnt at the stake for causing the plague by poisoning wells. Today, he said, men were on trial for a similar reason. Asked by von Drigalski how he accounted for typhoid outbreaks in military barracks, where the floors were of concrete and gravel, Emmerich replied that the troops brought the [matured] bacilli in with their boots.

It was then the turn of Koch to testify. He was, he said, "absolutely not a drinking-water fanatic and definitely not committed to any particular theory." He relied only on facts and proofs. These facts were the explosive nature of the epidemic, the even distribution of cases in a particular area among people who had not been in contact with each other, and the exact correspondence of the affected area with the piped water supply. Koch was relying essentially on the arguments put forward by John Snow in regard to cholera half a century before.

The defence then wound up its case. The hearings had shown, it maintained, that epidemic was not the work of men, but an Act of God. It was untrue that Pettenkofer's theory was outmoded, and in any case this was not a question to be decided by jurists. Nor should there be a blind faith in a single authority, whether it be Koch or Pettenkofer. Where such an attitude could lead had been shown by the enthusiasm in its time for Koch's tuberculin as a treatment for tuberculosis. Without belittling Koch's great services, cholera and typhoid were still problems about which "we must admit: *ignoramus*—or we do not know." A second counsel for the defence asserted that had the case been heard 10-11 years before Pettenkofer would doubtless have appeared as the principal expert witness, and would have been supported by the whole of the official and non-official medical world, who would have revolved around him "as the stars and the sun." Who could say whether or not in 10 years' time the same would happen to Koch's school as had happened to Pettenkofer's?

Outcome of the Trial

The public prosecutor had demanded sentences of two months' imprisonment for Hegeler, three months each for Pfudel and Schmitt, and a fine of 500 marks for Kiesendahl. But in the course of these protracted judicial proceedings it became obvious that the lawyers—and even the judge—could not arbitrate on purely scientific controversies. The prosecution therefore dropped the more serious charges of damaging health and causing risk to life, retaining only that of adulterating a "foodstuff" and leaving open the question of whether such adulteration had occasioned the epidemic.

Whether or not its action was responsible for the typhoid epidemic, it was indisputable that the water company had adulterated the filtered drinking water supply with untreated water from the Ruhr, and for this Hegeler got off with a fine of 1,200 marks, Pfudel and Schmitt each with 1,500 marks, and Kiesendahl with only 200 marks. But the defendants had to share the costs of the lengthy process.

Conclusion

The interest of this case is that there could have been at such a late date as 1904 any doubt about the mode of transmission of typhoid and cholera, and that this should have been an issue hotly argued in a court of law. In all the books of medical history the facts are grossly oversimplified. Koch, it is said, "discovered" the cholera vibrio in 1884 and one is left with the impression that that was the end of the matter. The truth is quite otherwise. For many years antagonists of Koch were almost as vocal as protagonists in regard to diseases that we now know to be primarily water-borne. The history books also give the impression that John Snow's epidemiological researches were almost universally accepted—whereas the converse in true.

Even in 1912 Georg Sticker,[16] in his standard work on cholera of almost 600 pages, derided the "drinking-water theory," saying: "The most fundamental refutation of the false doctrine of drinking-water epidemics is to be found in the works of Wolter. He and Emmerich have finally liquidated the drinking-water hypothesis." And Arnold C. Klebs[17] wrote in 1917: "Pettenkofer's x we have found but the equally important y and z have yet to be supplied in the aetiologic formula."

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